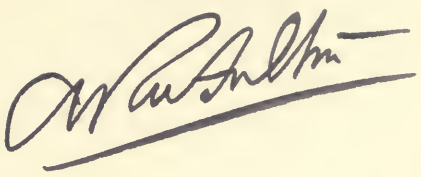
Baldwin Locomotive Works.

Illustrated Catalogue

OF

Narrow-Gauge Locomotives



BALDWIN LOCOMOTIVE WORKS.

(BIRD'S-EYE VIEW.)

A CATALOG FOR NARROW GAUGE LOCOMOTIVES.

74. [BALDWIN LOCOMOTIVE WORKS]. ILLUSTRATED CATALOGUE OF NARROW-GAUGE LOCOMOTIVES. BURNHAM, PARRY, WILLIAMS & CO. Philadelphia: J. B. Lippincott & Co., 1885. 64 pages of text plus 16 mounted albumen photographs. The images measure 8 x 5 inches (203 x 127 mm.) and are by an unknown photographer. Quarto, 11 x 7½ inches (279 x 191 mm.). Gilt and black on flexible maroon cloth; inner hinge cracked.

Third edition. The Baldwin Locomotive Works of Philadelphia was the oldest and largest locomotive producer in the United States. The firm employed 2,000 highly skilled workers, had delivered 4,000 engines since its founding by abolitionist and watchmaker Matthias Baldwin in 1831, and provided engines to large and small railroads in the U.S. as well as railroads overseas.

Narrow gauge track was smaller and less expensive than standard gauge and used extensively in the mountainous regions of the American West and in Latin America. The narrow gauge catalogs from Baldwin Locomotive Works are uncommon, with no mention of them by Romaine in *American Trade Catalogs*. There are four copies located on OCLC for this third edition, but no mention of earlier editions. The words "third edition" possibly meant the third catalog issued by the company.

$3,000.

BALDWIN LOCOMOTIVE WORKS.

ILLUSTRATED CATALOGUE

OF

NARROW-GAUGE LOCOMOTIVES.

BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA., U.S.

GEORGE BURNHAM, CHARLES T. PARRY, EDWARD H. WILLIAMS, WILLIAM P. HENSZEY, EDWARD LONGSTRETH, JOHN H. CONVERSE.

THIRD EDITION.

PHILADELPHIA:

J. B. LIPPINCOTT & CO.

1885.

ADVERTISEMENT.

Separate Catalogues or Circulars are issued, and will be furnished on application, with particulars of

BROAD-GAUGE LOCOMOTIVES.

NARROW-GAUGE LOCOMOTIVES.

MINE LOCOMOTIVES.

COMPRESSED AIR LOCOMOTIVES.

LOCOMOTIVES FOR SUGAR PLANTATIONS.

LOCOMOTIVES FOR LOGGING RAILROADS.

LOCOMOTIVES FOR ROLLING MILLS, CONTRACTORS' USE, AND OTHER SPECIAL SERVICE.

NOISELESS MOTORS AND STEAM-CARS FOR CITY RAILWAYS.

BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS,

PHILADELPHIA, PA.

CONTENTS.

CIRCULAR.

IN the following pages we present and illustrate a system of NARROW-GAUGE LOCOMOTIVES, in which, it is believed, will be found designs suited to all the requirements of ordinary service.

These patterns admit of modifications, to suit the preferences of railroad managers, and where machines of peculiar construction for special service are required, we are prepared to make and submit designs, or to build to specifications furnished.

All the locomotives of the system herewith presented are adapted to the consumption of wood, coke, or bituminous coal as fuel. Where coal, either bituminous or anthracite, is used exclusively as fuel, a modification in the plan of engine and in the form of fire-box can be made in the principal classes, as will be seen by reference to the classes described on page 21.

All work is accurately fitted to gauges, which are made from a system of standards kept exclusively for the purpose. Like parts will, therefore, fit accurately in all locomotives of the same class.

This system of manufacture, together with the large number of locomotives at all times in progress, and embracing the principal classes, insures unusual and especial facilities for filling at once, or with the least possible delay, orders for duplicate parts.

The advantages and economies to the *users of locomotives* resulting from this method of construction are apparent. By its means the expense of maintenance and repairs can be reduced to a minimum. A limited stock of duplicate parts, either ordered with the locomotive or at any time thereafter, can be kept on hand by the purchaser and drawn from to replace any worn-out or broken part when required. Repairs can thus be made in the shortest possible time, and the use of the locomotive lost for only a few hours or days, or not at all. The first cost of duplicates will be much less than the cost of manufacture in the shop of the railroad company; in many cases it will be less than

the cost of carrying the stock of raw material necessary for the purpose; while, if the line is equipped with a limited number of classes of standard interchangeable locomotives, the quantity of duplicates necessarily carried in stock will be small and comparatively inconsiderable in the amount of capital represented. Much of the ordinary outlay for shops, machinery, drawings, and patterns can be saved, and the necessity of maintaining for the purpose of repairs a large force of skilled workmen at a constant expense may be in great measure obviated.

Particulars of the performance of various classes of locomotives illustrated will be found in the body of the Catalogue. It will be seen from these statements of work actually done that at least nine-fortieths of the weight on driving-wheels are utilized for adhesion, under ordinarily favorable conditions, with adequate boiler and cylinder capacity. The loads given in the tables are, therefore, calculated for each class on this basis, in tons of twenty-two hundred and forty pounds, and are predicated on track being straight and in good condition. It is also assumed that the frictional resistance of the cars hauled will not exceed eight pounds per gross ton of their weight.

Designs and estimates for any sizes or patterns of locomotives not given in this Catalogue will be submitted on application.

The delivery of locomotives at any point which can be reached by rail or vessel will be included in contracts if desired.

In ordering locomotives, the following particulars should be given:

1. Gauge of track,—exact inside distance between the rails.
2. Kind of fuel which will be used.
3. Kind and height of couplings of cars.
4. Limitations, if any, in width, height, etc., by tunnels, overhead bridges, etc.
5. Mark, name, or number.

For detailed specifications and further particulars, address

BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS,

PHILADELPHIA, PA., U. S.

CLASS DESIGNATIONS.

THE different classes of locomotives are designated by a combination of figures with one of the letters C, D, E, or F, so as to indicate both the plan and size, as follows:

The letter	C	indicates	that	four	wheels	are	connected	as driving-wheels.
"	D	"	"	six	"	"	"	
"	E	"	"	eight	"	"	"	
"	F	"	"	ten	"	"	"	

1. A figure or figures (4, 6, 8, 10, or 12) is used to indicate the whole number of wheels under the locomotive.

2. A figure or figures, following the figures indicating the whole number of wheels, indicates the diameter of cylinders, viz.:

8	indicates	cylinders	7	inches	in diameter.
10½	"	"	8	"	"
11 and 12	"	"	9	"	"
14	"	"	10	"	"
16	"	"	11	"	"
18 and 18½	"	"	12	"	"
20	"	"	13	"	"
22	"	"	14	"	"
24	"	"	15	"	"
26	"	"	16	"	"
28	"	"	17	"	"
30	"	"	18	"	"

Thus 8-18 C indicates an eight-wheeled locomotive, having four wheels coupled, and cylinders twelve inches in diameter. 8-22 D indicates an eight-wheeled locomotive, having six wheels coupled, and cylinders fourteen inches in diameter; and 10-26 E, a ten-wheeled locomotive, having eight wheels coupled, and cylinders sixteen inches in diameter.

The addition of the fraction ¼ indicates that there is a truck at each end of the locomotive. Thus 8-18¼ C indicates an eight-wheeled locomotive, having four wheels coupled, cylinders twelve inches in diameter, and a two-wheeled truck at each end.

The addition of the fraction ⅓ indicates that the engine is on the "Forney" plan, having the truck back of the fire-box. Thus 8-16⅓ C indicates an eight-wheeled locomotive, having four wheels coupled, cylinders eleven inches in diameter, and a four-wheeled truck back of the fire-box. 6-16⅓ C indicates a six-wheeled locomotive, having four wheels coupled, cylinders eleven inches in diameter, and a two-wheeled truck back of the fire-box.

The figures following the class designation, as found on every locomotive, give the *class number* for that locomotive, and supply an individual designation for it, in addition to the construction number. Thus 8-20 C 500 means the five-hundredth locomotive of the 8-20 C class.


HOLGUIN
275

PASSENGER AND FREIGHT LOCOMOTIVES, "AMERICAN" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Photograph on page 8.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
										26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. *In.*	*Ft.* *In.*											
8-14 C	10 × 16	39 to 43	6 5	17 3½		1000	33,000	22,000	535	210	125	85	60	45	35
8-16 C	11 × 16	39 to 43	6 9	17 10		1100	36,000	24,000	645	250	150	100	75	55	40
8-18 C	12 × 16	39 to 43	7 2	18 3		1200	39,000	26,000	700	275	160	110	80	60	45
8-18½ C	12 × 18	41 to 45	7 6	18 7		1400	42,000	28,000	750	295	175	120	85	65	50
8-20 C	13 × 18	41 to 45	7 10	19 3		1500	45,000	30,000	805	315	185	130	95	70	55
8-22 C	14 × 18	41 to 45	8 2	20 1		1600	48,000	32,000	860	335	200	140	100	75	60

In locomotives of this pattern all the wheels are usually flanged. Where, however, very short curves have to be traversed, the front driving-wheels can be made without flanges.

The total wheel-base of engine, with 8-wheeled tender attached, varies from 34 feet 8 inches for Class 8-14 C to 39 feet 9 inches for Class 8-22 C. From 18 inches to 2 feet should be added to give the length of turn-table required.

PERFORMANCE OF NARROW-GAUGE LOCOMOTIVES, "AMERICAN" TYPE.

THE following data will serve to indicate the kind and extent of work performed by narrow-gauge locomotives of the "American" type:

CLASS 8-16 C ON GRADE OF 116½ FEET PER MILE.

NEVADA COUNTY NARROW-GAUGE RAILROAD.
GENERAL SUPERINTENDENT'S OFFICE, GRASS VALLEY, CAL., October 26, 1877.

MESSRS. BURNHAM, PARRY, WILLIAMS & Co.:

Gentlemen,—Our engine, "Grass Valley, No. 1" (Class 8-16 C), hauls mixed trains over our road. Maximum grade in direction of freight movement is 116½ feet per mile; minimum radius of curvature, 302.9 feet. These trains consist generally of three freight box cars, one smoker and baggage combined, and one passenger car. Our box cars weigh 4 gross tons each, and are loaded with 8 gross tons each. The passenger and smoking cars are each 42 feet long from outside of platforms. A passenger coach seats 32 passengers. I do not know the exact weight of these cars, but estimate at least 11 gross tons each, and loaded at 13 gross tons each.

The weight of train is as follows, viz.:

Three loaded box cars, 12 gross tons each	36 tons.
One combined smoker and baggage, and one passenger coach, 13 gross tons each	26 "
Total weight of train	62 tons.

The same engine has brought over the road on several occasions four loaded box cars and the smoker and passenger cars, and has likewise hauled, when running extra, six loaded box cars.

The mixed trains first above-mentioned run from Colfax to Nevada, 22½ miles, in two hours, making an average of four stops, one at Grass Valley of ten minutes. Absolute running time, one hour and forty minutes, or an average of 13½ miles per hour.

This locomotive, as you are aware, has been in commission for over two years; seven months of the time on construction and the balance in regular service. It has had the tire turned once, and to-day is in as good condition as when she came on the road.

Our locomotive, "Nevada, No. 2" (Class 8-16 D), hauls over the same road seven loaded box cars.

Our rail weighs 35 pounds per yard. Total degrees of curvature on line are 7944° 25′. Total length of tangents, 53,908 feet. Total ascents from Colfax, 1159 feet. Total descents from Colfax, 1042 feet.

Yours truly,

JOHN F. KIDDER,
General Superintendent.

CLASS 8-16 C ON GRADE OF 75 FEET PER MILE.

On the Denver and Rio Grande Railway, locomotives of Class 8-16 C were used for passenger service until the increase of traffic required heavier engines. Following is extract of a letter, dated February 13, 1877, from W. W. Borst, then General Superintendent of the line:

"Passenger engines Nos. 16, 17, 18 (Class 8-16 C). These engines are used on our regular passenger trains, consisting of one baggage car and two coaches, at a speed of 20 miles per hour on all grades. We have never had occasion to test either the speed or the power of these engines in passenger train service.

"On the 29th of August, 1876, Engine No. 16 took one baggage car, five coaches, and one excursion car from Denver to Colorado Springs. Time, including stops, four hours; actual running time, about three and a half hours. She did her work with ease, making 20 miles per hour on the heaviest grades. I am satisfied that either of the four-wheels-connected passenger engines will haul seven coaches and one baggage car, over our 75 feet grades, at from 18 to 20 miles per hour.

"These engines are as heavy as should be run over a 30 pound iron rail, although I do not see that they injure the iron more than our lighter engines. When the road-bed is soft, these engines knock the track out of line more than our first engines (6-12 C)."

CLASS 8-16 C ON GRADE OF 110 FEET PER MILE.

On the Camden, Gloucester and Mount Ephraim Railway, 3 feet gauge, laid with 35 pound rails, a locomotive of Class 8-16 C has hauled five loaded eight-wheeled freight cars and two loaded passenger cars up a grade of 110 feet per mile. The usual train is two passenger cars, with which the run is made from Gloucester to Camden, 2½ miles, in twelve minutes, making four regular intermediate stops, and running slow into the city of Camden. One curve of only 120 feet radius occurs on entering Camden.

CLASS 8-18½ C ON GRADES OF 52 TO 105 FEET PER MILE.

On the Eureka and Palisade Railroad, 3 feet gauge, of Nevada, a locomotive of Class 8-18½ C, with one passenger coach attached, has made the run from Palisade to Eureka, 90 miles, in two hours and thirty-eight minutes, nearly all the distance being up grade, viz.: 52 feet per mile for 35 miles, 75 feet per mile for 8 miles, and 105 feet per mile for 3 miles. Average speed, 34.17 miles per hour.

CLASS 8-18½ C ON GRADES OF 155 FEET PER MILE, AND CURVES OF 215 FEET RADIUS.

A locomotive of Class 8-18½ C was in daily use for one hundred and fifty-six days, from May 13, 1876, to the close of the Exhibition, on the narrow-gauge railway in the Centennial Exhibition grounds. The line was 3½ miles long, with double track, and was made up almost wholly of curves in order to run near all the principal buildings on the Exhibition grounds. Many of the curves were on the heaviest

grades, some having a radius of 215, 230, and 250 feet on grades of 140 and 155 feet per mile. The track was laid with iron rails weighing 35 pounds per yard. The usual load of the engine was five eight-wheeled passenger cars, frequently carrying over 100 passengers per car. On special occasions as many as six and seven loaded cars have been drawn by one of these engines. The average weight of each loaded car was about 12 gross tons.

CLASS 8-22 C ON GRADE OF 80 FEET PER MILE.

CARSON AND COLORADO RAILROAD CO.
CARSON CITY, COL., March 18, 1881.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Dear Sirs,—Engines Nos. 1 and 2 have pulled a train of twenty-one loaded cars, of 10 tons each, over a grade of 80 feet to the mile, which I consider extraordinarily good work.

(*Signed*) H. M. YERINGTON,
President.


SOUTH 12 FLORIDA.
12
211

PASSENGER AND FREIGHT LOCOMOTIVES, "TEN-WHEELED" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Photograph on page 14.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
10-22 D	14 × 20	45	12	21		1600	53,000	40,000	1080	430	255	175	130	100	80
10-24 D	15 × 20	45	12 5	21 5		1800	58,000	44,000	1190	470	280	195	145	110	90
10-26 D	16 × 20	45	12 9	21 9		2000	64,000	48,000	1300	515	310	210	160	120	100

This type of locomotive is offered for passenger, freight, or mixed service, where a locomotive of the "American" type, with four coupled wheels, does not give sufficient power. The greater length of the engine admits of a longer boiler, and therefore gives increased heating surface. As the increased weight is carried on an additional pair of driving-wheels, the weight on each wheel is not excessive, and is, in fact, less than the weight on each wheel of the "American" locomotive of corresponding cylinder.

The total wheel-base, with 8-wheeled tender attached, varies from 40 feet 6 inches for Class 10-22 D to 43 feet for Class 10-26 D. From 18 inches to 2 feet should be added, to allow for clearance of flanges, to give the length of turn-table required.

The driving-wheels can be made with flanges on the front and back pairs and without flanges on the middle pair, or with flanges on the middle and back pairs and the front pair without flanges. The truck can be made with swinging bolster, where required for passing short curves; otherwise, a rigid-centre truck with middle and back pairs of driving-wheels flanged will give good results.

PERFORMANCE OF NARROW-GAUGE "TEN-WHEELED" PASSENGER LOCOMOTIVES.

CLASS 10-22 D ON GRADES OF 90 FEET PER MILE.

DENVER AND RIO GRANDE RAILWAY CO., BURNHAM, COL., February 1, 1882.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO., PHILADELPHIA, PA.:

Gentlemen,—We now have four of the "ten-wheelers" on our regular express trains between Denver and Pueblo (120 miles), and have made the run in five hours. Train consisted of mail, express, baggage, and three coaches—six cars in all. Weight of train, 70 tons. Maximum grade, 90 feet per mile, 5 miles long; 26 miles of 75 feet grade. This I consider a very satisfactory performance by comparison with the 14 x 20 cylinder "Moguls."

The 12 feet wheel-base seems to be no objection on this part of the line. They curve readily, ride easily, and, so far as trial has been given, are a very satisfactory engine.

Respectfully, N. W. SAMPLE, *Superintendent M. P. & M.*

DENVER AND RIO GRANDE RAILWAY COMPANY, DENVER, COL., May 1, 1884.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO., PHILADELPHIA, PA.:

Dear Sirs,—Your letter of April 25th at hand yesterday. We have been using these engines (Class 10-22 D) between Denver and Pueblo on regular passenger trains; distance, 120 miles, 51 miles of which are 52 feet grade; maximum curvature, 12° per 100 feet; 19 miles 75 feet grade; maximum curvature, 6°; 24 miles running from 75 to 90 feet per mile (6 miles of 90 feet); maximum curvature, 6°; 26 miles 42 feet grade.

Over this line we hauled with Engine 166, on last year's card, a train of ten mail, express, baggage cars, and coaches, total weight of which was 284,550 pounds, exclusive of lading, in five hours and ten minutes. This train, however, was an exceptional one, the average on that card being eight cars.

The cars in our present fast train for Salt Lake City and Ogden weigh, exclusive of lading, 182,000 pounds, and the running time between Denver and Pueblo is four hours and ten minutes. This is made easily, and has been made with one car more (about 27,000 pounds) under particularly favorable conditions. We are also running this engine between Pueblo and Salida on the same maximum grade, 75 feet per mile; maximum curvature, 15° per 100 feet (and an immense amount of it); distance, 96 miles; time, three hours and forty minutes; in which service they have given excellent satisfaction.

Yours truly, (*Signed*) N. W. SAMPLE, *Superintendent M. P. & M.*

THE SOUTH FLORIDA RAILROAD CO., SANFORD, FLA., May 24, 1884.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO., PHILADELPHIA:

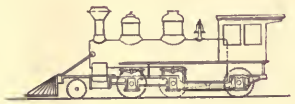
Dear Sirs,—Replying to your favor of April 25th, would say that we find the average cost of maintenance per mile of Engines Nos. 10, 11, 12, and 13, your ten-wheelers, to be 10⅔ cents. The average cost of wood per mile is 4½ cents. One of the engines, No. 10, since November, 1883, to May 1, 1884, has run a total of 13,541 miles on an average cost of $10\frac{2}{10}$ cents per mile, including $4\frac{53}{100}$ cents per mile for wood. We find the engines have given entire satisfaction, are easily handled, extremely powerful, and, for their size and weight, easy upon the track. We have had no trouble with the extended arch, and our engineers claim that by its use there is no back pressure on the cylinders; can raise steam quicker and hold steam longer than any other class of engine. It is not uncommon to find gauge showing 20 pounds steam upon starting fire up in the morning, eight to ten hours after run is over.

Very truly yours, (*Signed*) J. E. INGRAHAM, *President.*

These figures of cost per mile run include items as follows: Engineers, firemen, all repairs, fuel, oil, waste, tallow, and the general maintenance.

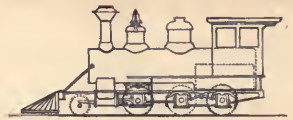

AURAS


ESTRADA DE FERRO PIRAHYENSE.
RIO CLARO
229



FREIGHT LOCOMOTIVES, "MOGUL" TYPE.

GAUGE, THREE FEET OR WIDER FUEL, WOOD OR COAL.



General Design shown by Photographs on pages 18 and 20.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF FIVE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base. Of Driving-Wheels.	Wheel-Base. Total.	Capacity of Tank for Water. 8⅓-Pound Gallons. Tank on Boiler or Engine Frames.	Capacity of Tank for Water. 8⅓-Pound Gallons. Separate Tender.	Weight in Working Order. Pounds. Total.	Weight in Working Order. Pounds. On all Driving-Wheels.	LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING. On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-16 D	11 × 18	36 to 41	11 4	17 4		1000	35,000	29,000	785	315	190	130	100	75	60
	11 × 18	36 to 41	8 7	14 3		1000	35,000	29,000	785	315	190	130	100	75	60
8-18 D	12 × 18	36 to 41	11 8	17 8		1200	40,000	33,000	895	355	215	150	110	85	70
	12 × 18	36 to 41	8 8	14 8		1200	40,000	33,000	895	355	215	150	110	85	70
8-20 D	13 × 18	36 to 41	12	17 10		1400	46,000	39,000	1060	420	255	175	130	100	80
	13 × 18	36 to 41	9 2	15 2		1400	46,000	39,000	1060	420	255	175	130	100	80
8-22 D	14 × 18	36 to 41	12	18 4		1500	50,000	42,000	1140	455	275	190	140	115	90
	14 × 18	36 to 41	9 8	15 8		1500	50,000	42,000	1140	455	275	190	140	115	90
8-24 D	15 × 18	36 to 41	12 6	18 6		1600	56,000	48,000	1300	520	315	220	165	130	105
	15 × 18	36 to 41	10	16 6		1600	56,000	48,000	1300	520	315	220	165	130	105

In the above table two types of locomotives are given for each class. The difference is in the form of the fire-box and in the driving-wheel-base, which is affected by the form of fire-box. A shallow fire-box placed on top of the frames allows the driving-wheels to be placed close together, and so gives a short wheel-base where required for passing very short curves. (See photograph on page 20.) The shallow fire-box answers nearly every purpose where coal is the fuel, but where wood is used for fuel the deeper fire-box is preferred. (See photograph on page 18.) The deeper fire-box is also generally preferred for bituminous coal where the longer driving-wheel-base is not objectionable. It should be noted, however, that in some cases where a short driving-wheel-base is especially important, the shallow fire-box has been used successfully for burning wood.

In referring to any of the above classes, please be particular to specify the wheel-base, or otherwise designate whether the shallow or deep fire-box type is wanted. In locomotives of the above classes the front and rear driving-wheels must be flanged. The main pair have no flanges. The pony truck has a swinging bolster and radius bar, so that it can move laterally in passing a curve. The total wheel-base, with 8-wheeled tender attached, varies from 34 feet 3 inches for Class 8-16 D to 39 feet for Class 8-24 D. From 18 inches to 2 feet should be allowed for clearance of flanges, to give length of turn-table required.

PERFORMANCE OF NARROW-GAUGE "MOGUL" LOCOMOTIVES.

CLASSES 8-16 D AND 8-18 D ON GRADES OF 146 TO 211 FEET PER MILE.

MINERAL RANGE RAILROAD COMPANY.
HANCOCK, MICH., February 19, 1877.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
PHILADELPHIA:

Gentlemen,—In reply to your inquiry relative to the working of the last engine furnished us, we would say that we use the "Sharpless" for freight service, the "Portage Lake" for passenger service, and the "Keweenaw" as a spare engine. I will give you the service of the "Sharpless," from which we can judge of the "Keweenaw" by comparison.

Our road is 12½ miles long. We leave the station at Hancock on a grade of 211 feet to the mile, which continues for a distance of about 1200 feet. We pass from this 211 feet grade to one of 146 feet to the mile, which latter grade continues for a distance of about 2 miles, after which the maximum grade is 60 feet to the mile, reaching an altitude at Calumet, the other end of the road, of 630 feet above the starting-point. The curve of 410 feet radius occurs upon the 146 feet grade.

The snow commences falling in November usually, and continues to fall steadily until January or February, with occasional heavy storms after that time, with high winds and heavy drifts. Sleighing comes with the first fall of snow, and continues until April, and sometimes until the early part of May. By first of January we have from 1½ to 3 feet of snow, and it is not an unusual thing to find 3½ to 4 feet of snow in the woods on the first of April. This is our average winter. The present winter is the mildest we have experienced since 1857 and 1858.

During the winter of 1875, with very heavy snows, high winds, and the mercury ranging from 0° to 35° below for over forty days, we were only delayed, all told, about three days; that is, the Smelting Works and Stamp (Crushing) Mills, to which we brought their daily supplies of material, were stopped, on account of our inability to get through, only about three days.

In exposed places on the 146 feet grade the snow often drifts to the depth of 3½ to 5 feet on the track, and becomes so hard that one could walk upon it as easily as upon a floor. With the "Sharpless" provided with a small iron plough, we have often worked up grade, clearing the road of these drifts, and to good effect. She would go into them for a distance of 200 to 500 feet each run before the snow would stop her by getting under the drivers and causing the engine to slip.

With this explanation of the difficulties we are called upon to surmount in operating our road, you will be able to judge intelligently of the service of the engines. We are now hauling about 90,000 tons of freight per annum, or, at that rate, say 12,000 tons from Hancock up grade, and 70,000 tons of copper rock and 8000 tons of copper down grade. The copper is transported upon eight-wheeled freight cars, and the rock in eight-wheeled hopper cars, the cars weighing each 6¼ tons empty, and 18¾ tons loaded.

The "Sharpless" (12 × 16 cylinders, 36 inch drivers) will draw up the 211 feet grade ten empty hopper cars. Total weight, 62½ tons. On the 146 feet grade, which includes the curve of 410 feet radius, with a good rail, the same engine draws regularly twelve empty hopper cars. Total weight, 75 tons.

Its usual load on the 60 feet grade is 12 empty rock cars and 6 loaded freight cars. Weight, about 150 tons going up. The usual down freight train consists of 12 loaded rock cars and from 6 to 8 cars of copper. Weight of cars and lading, say for 18 cars, 305 tons; 20 cars, 332 tons.

This is our regular work, unless the rail is unusually bad by reason of snow or frost.

The capacity of the "Keweenaw" (12 × 16 cylinders, 40 inch drivers) on the 211 and 146 feet grades is about 6 to 12 tons less, as near as we can judge. For freight service we consider the "Sharpless" the best; for passenger service the "Keweenaw" excels. The larger boiler causes her to steam easily, and her greater weight to run very steadily.

The "Portage Lake" (11 × 16 cylinders, 36 inch drivers) draws two coaches, weight 15 tons, and one freight car, weight say 12 to 14 tons, and makes the trip from Hancock to Calumet in fifty minutes. Deducting stops, this would make running time about forty to forty-five minutes. We use this engine in passenger service, as the other engines, being larger, are more desirable for heavy work.

We consider that with the "Sharpless" we can transport in one year, making two round trips over the road per day, 100,000 tons of freight down grade, and 30,000 tons up grade, the work all to be done between 7 A.M. and 6 P.M., and by the "Sharpless" alone. By adding one more trip, time required, four hours, the service would be increased 33 to 50 per cent.

Our rail weighs 35 pounds per yard, which we consider heavy enough for the engines. When we renew we shall use a heavier rail, and increase the weight of freight engines purchased in future.

To sum up, your engines have given perfect satisfaction, and we do not see in what manner they could be improved. Our service, with the grades, snow, and ice, is very hard, but the engines have never failed. I have written at length that you might fully understand what we are doing, and will be very glad to answer any further inquiries you may be pleased to make.

Very truly yours,

(*Signed*) CHARLES E. HOLLAND.

MINERAL RANGE RAILROAD COMPANY.
HANCOCK, MICH., March 10, 1877.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
PHILADELPHIA:

Gentlemen,—I omitted to state in my last letter that we have two curves of 410 feet radius combined with the 146 feet grade, up which the "Sharpless" hauled the twelve hopper cars. One of the curves occurs on the side track going into the mill, and the other on the main line. Since writing you I have looked up the actual weight of the hopper cars, as weighed upon a Fairbanks track scale at the mine, and find that the twelve cars weighed $75\frac{1410}{2000}$ tons. Since that weight was made, additions of running boards and changes have been made which increased the weight, and fourteen more cars have been purchased which were made a little heavier. As the cars are all mixed together, we conclude that 76½ tons would be about the actual weight of twelve cars, in place of 75 tons, as reported. Further, twelve cars is the greatest number we have to haul at one time, and the "Sharpless" hauls them up this 146 feet grade, combining the two curves of 410 feet radius, with great ease, with 120 pounds pressure on boiler, and the engineer informs me that when we have a greater number of cars he can haul fourteen cars, weighing, say, 89 to 90 tons, with the "Sharpless" by increasing the steam pressure to 130 pounds. This we fully expect to do when our trains become larger.

Since writing you, a trial was made with the "Portage" on the 211 feet grade. She hauled four cars loaded with copper up the grade with ease, cars and lading weighing 48 tons of 2000 pounds, good and strong, and the master mechanic says she will haul one car more, or 12 tons additional. This, you will observe, exceeds the capacity of the "Sharpless" named in your letter.

Now, an instance of speed made by the "Keweenaw," August 21, 1876, with one coach weighing 7½ tons: ran from Hancock to Calumet, 12½ miles, in twenty minutes; deduct one and one-quarter minutes for one full stop would leave eighteen and three-quarter minutes running time, or an average speed of 40 miles per hour. The time made on the 211 and 146 feet grades was 30 miles per hour, on

the 60 feet grade from 40 to 60 miles per hour, one mile being run in just one minute. The work did not seem to crowd the engine, and we can see no reason why it could not be done daily if desired. The train ran very smoothly, and the only inconvenience experienced was from dust.

Very truly yours,

(*Signed*) CHARLES E. HOLLAND,
President.

CLASS 8-18 D ON GRADES OF 75 AND 90 FEET PER MILE.

DENVER AND RIO GRANDE RAILWAY CO., OFFICE OF SUPERINTENDENT.
DENVER, COL., February 13, 1877.

GEN. WM. J. PALMER, President D. and R. G. Railway Co.:

Dear Sir,—In reply to letter of Burnham, Parry, Williams & Co., in reference to the performance of our last engines, I have to say,—

1. Freight Engines Nos. 13, 14, 15, and 19 (Class 8-18 D). The average train for these engines is twelve loaded box or thirteen loaded coal cars and caboose; each load, 8 tons (coal cars, 3½ tons; box cars, 4 tons); or 150 tons of cars and lading, at a speed of 8 to 10 miles per hour.

Our average freight train time on present card is 10 miles per hour between Denver and Pueblo. On heavy grades the speed is reduced to 8 miles, and on slightly descending grades and levels the speed is increased to 12 miles.

We have, when rail and cars were in perfect condition, hauled fifteen loaded cars at about 6 miles per hour.

2. Passenger Engines Nos. 16, 17, and 18 (Class 8-16 C). These engines are used on our regular passenger trains, consisting of one baggage car and two coaches, at a speed of 20 miles per hour on all grades. We have never had occasion to test either the speed or the power of these engines in passenger train service.

On the 29th of August, 1876, Engine 16 took one baggage car, five coaches, and one excursion car from Denver to Colorado Springs. Time, including stops, four hours; actual running time, about three and one-half hours. She did her work with ease, making 20 miles per hour on the heaviest grades. I am satisfied that either of the four-wheeled-connected passenger engines will haul seven coaches and one baggage car over our 75 feet grades at from 18 to 20 miles per hour.

These engines are as heavy as should be run over a 30 pound iron rail, although I do not see that they injure our rail more than our lighter engines.

When the road-bed is soft, these engines knock the track-bed out of line more than our first engines.

Respectfully yours,

(*Signed*) W. W. BORST,
Superintendent.

CLASS 8-18 D ON GRADE OF 105 FEET PER MILE.

ELBERTON AIR-LINE RAILROAD CO., GENERAL MANAGER'S OFFICE.
ATLANTA, GA., May 4, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The Elberton Air-Line Railway, which connects with the Atlanta and Charlotte Air-Line Railway at Toccoa, is 50 miles long, of 3 feet gauge, laid with T rails weighing 30 pounds per yard, and has maximum grades of 2 per cent. (105 feet per mile), ½ mile in length. The shortest curves are 970 feet radius. On the maximum grade of 2 per cent. there is one curve of 1433 feet radius, 350 feet long.

The line is worked by two "Mogul" locomotives of your Class 8-18 D (cylinders, 12 × 16; driving-wheels, 3 feet diameter). Each engine hauls on the grades and curves stated fifteen loaded cars, each weighing with its lading about 15,000 pounds.

Yours truly,

(*Signed*) G. J. FOREACRE,
General Manager.

CLASS 8-18 D ON GRADES OF 86 TO 105 FEET PER MILE.

PEACH BOTTOM RAILROAD.
YORK, PA., February 2, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Dear Sirs,—I enclose a statement of 2¾ miles of our road, over which the No. 4 hauled the load referred to, together with grades, curves, radius, and length of each curve.

1st mile. Average grade, 86.6 per mile, on which we have two 10° curves, each 400 feet in length; two 14° curves, each 450 feet in length; one 9° curve, 500 feet long.

2d mile. Grade, 105 feet, with two 10° curves, each 500 feet in length; one 7° curve, 250 feet long; and one 5° curve, 400 feet long.

On the last ¾ mile. 1500 feet 95 feet grade, with one 14° curve, 650 feet long, reversing on another 14° curve, 400 feet in length, with 75 feet tangent, followed by a 10° curve, 350 feet long.

Last ½ mile. Grade, 105 feet per mile, with two curves, one 6° and the other a 3° curve, each 400 feet in length.

Train hauled, seven eight-wheeled gondolas and one passenger coach; total weight, 90 tons. Pressure at start, 100 pounds; when at top of grade, 100 pounds. Speed, 10 miles per hour, being our regular schedule.

Our engineer thinks he could have hauled two cars more with pressure at 125 pounds. I do not consider the above as a test of what the engine is capable of doing, and shall be pleased to inform you of future performance on the same piece of road.

November 7, 1878.

Yesterday the No. 4 hauled a train of ten cars (over the same piece of road I sent you particulars of), consisting of four eight-wheeled box cars, five eight-wheeled gondolas, and one passenger coach; total weight, 211,190 pounds, actual weight; equal to 94 tons (2240 pounds) of cars and lading. Pressure at start, 125 pounds; at top of grade, 120 pounds. Speed, 10 miles per hour, including two stops at stations. The above load was hauled with ease. Shall be glad to inform you of any greater performance, as we have not yet tested her full capacity.

(*Signed*) S. M. MANIFOLD,
Superintendent.

CLASS 8-22 D ON GRADES OF 90 AND 160 FEET PER MILE.

BELL'S GAP RAILROAD.
BELLWOOD, PA., March 24, 1882.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Answering your favor of the 18th instant, would say that on the 23d instant, Engine No. 4 hauled a train of seven loaded Pennsylvania Railroad cars on narrow-gauge trucks up the grade of 90 feet, combined with 15° curves, on the western slope of the mountain. Train weighed 183 net tons; steam pressure, 125 pounds; speed, eight minutes to the mile. On the same date the engine hauled nine empty Pennsylvania Railroad car bodies on narrow-gauge trucks up the grade of 160 feet, combined with 28° curve, on the eastern slope of the mountain. Train weighed 70 tons, spread over a distance of 285 feet. Steam pressure and speed same as above. Sand had to be used freely on curves to prevent engine from slipping. An ordinary train up the western slope is six Pennsylvania Railroad car bodies on narrow-gauge trucks, and up the eastern slope eight empty broad-gauge cars at a speed of six minutes to the mile. The performance of Engine No. 4 has been very satisfactory. Engine weighs 52,000 pounds, with three gauges of water.

(*Signed*) R. G. FORD,
Superintendent.

CLASS 8-22 D ON GRADE OF 105 FEET PER MILE.

THE MEXICAN NATIONAL CONSTRUCTION CO.
NEW YORK, September 10, 1883.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Dear Sirs,—Mr. Lister states that our "Mogul" engines (14 × 20 cylinders) will take eight or nine loaded cars and a caboose from Gracia to Ojo Caliente,—about 2 per cent. grade,—but cannot make more than 8 or 10 miles per hour.

The eight or nine loaded cars and caboose spoken of by Mr. Lister will weigh from 145 to 150 tons, and between Gracia and Ojo Caliente the curves are about 11° maximum.

(*Signed*) W. M. SPACKMAN,
Assistant Purchasing Agent.


33
SILVER CLIFF
159

FREIGHT LOCOMOTIVES, "CONSOLIDATION" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, ANTHRACITE OR BITUMINOUS COAL.

General Design shown by Photograph on page 28.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF FOUR SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
										26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. *In.*	*Ft.* *In.*											
10-22 E	14 × 18	37	11 7	17 8		1500	52,000	44,000	1190	480	290	200	150	115	95
10-24 E	15 × 18	37	11 6	17 8		1600	56,000	48,000	1300	520	315	220	165	130	105
10-24½ E	15 × 20	37	11 6	17 8		1600	60,000	52,000	1415	565	340	235	180	140	115
10-26 E	16 × 20	37	11 9	18 1		1800	68,000	60,000	1630	655	395	275	205	160	130

This type of locomotive is built with two pairs of flanged driving-wheels, usually the front and back pairs; the other two pairs of coupled wheels having tires without flanges. The pony truck has a swinging bolster and radius bar. The engine is guided on curves by the operation of the swinging truck in connection with the front flanged driving-wheels.

The form of fire-box is especially adapted to the use of coal. In some cases, however, wood has been used as fuel with satisfactory results.

The total wheel-base of engine with 8-wheeled tender varies from 39 feet 7 inches for Class 10-22 E to 41 feet 5 inches for Class 10-26 E. Adding, say, 18 inches for clearance of flanges, a turn-table 41 feet diameter and 43 feet diameter will be required.

PERFORMANCE OF NARROW-GAUGE "CONSOLIDATION" LOCOMOTIVES.

CLASS 10-24 E ON GRADES OF 100 TO 163 FEET PER MILE.

SOUTH PACIFIC COAST RAILROAD COMPANY.
SAN FRANCISCO, July 7, 1882.

BALDWIN LOCOMOTIVE WORKS,
PHILADELPHIA, PA.:

Gentlemen,—Your favors of June 12th and 19th received. In reply to your inquiries as to performance of "Consolidation" Engine No. 13, I cheerfully make the following statement:

The engine is for wood or coal. We have used only redwood, the kind in common use here. The engine is at work on our mountain division; pulls eleven loaded cars without sand up a grade of about 1 mile, varying from 100 to 163 feet, from the mills to the main line, with one curve of 10°. Pulls fourteen loaded cars and one caboose up a 5 mile grade on the main line, varying from 70 to 90 feet, around 10° to 16° curves. The sharpest curve occurs on the heaviest grade in one instance. The road is crooked, with short intervening tangents between all curves. Steam gets low sometimes and the blower has to be used, but the engine can start with the fifteen cars at any point with 130 pounds steam without slipping and without the use of sand. With coal for fuel I have no doubt the engine would never want for steam. The cars weigh 5 tons each, and the load fully 10 tons to each car. The engine has given us entire satisfaction in every respect so far.

Very respectfully,

(*Signed*) A. H. FRACKER,
General Superintendent.

CLASS 10-24½ E ON GRADE OF 53 FEET PER MILE.

CONNOTTON VALLEY RAILWAY.
BOSTON, February 14, 1881.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The machines we have work well, and we prefer not to change the pattern or make. They take twenty-four loaded cars (12 to 13 tons each of paying load) up a grade of 52.8 feet per mile.

(*Signed*) C. G. PATTERSON,
General Manager.

CLASS 10-24½ E ON GRADES OF 75 TO 90 FEET PER MILE.

DENVER AND RIO GRANDE RAILWAY.
DENVER, COL., March 7, 1882.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
PHILADELPHIA, PA.:

Gentlemen,—Your letter of the 28th ult. is received. I cannot quite confirm the statement of your engineer. The engines you mentioned are our Class 60, and haul between Denver and Pueblo 262 tons (2000 pounds) of cars and lading. Allowing each car and its load to weigh 18 tons, this would be

almost fourteen and a half cars, as all cars are not loaded up to 24,000 pounds. It frequently happens that fifteen or sixteen cars are in train. 262 tons of cars and lading are the best they have done.

The maximum grade over this portion of our line is 75 feet, with unequated curves of 6°, making the grade on the curves equivalent to 90 feet per mile. The weight of the cars average about 6 tons empty, and when fully loaded they carry 12 tons freight.

Yours truly,

(*Signed*) D. C. DODGE,
General Manager.

CLASS 10-24½ E ON A GRADE OF 4 PER CENT.

SANTA ANA RAILWAY.
SONSONATE, SALVADOR, January 18, 1884.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The "Armenia" is doing good service. She starts and readily handles seven loaded cars (75 tons) on straight grade of 4 per cent. We are well pleased with her.

(*Signed*) A. J. SCHERZER,
Chief Engineer.

CLASS 10-26 E ON GRADE OF 158 FEET PER MILE.

THE PARANA RAILROAD, MORRETES, September 11, 1883.

TO THE DIRECTOR OF THE PARANA RAILROAD:

Dear Sir,—I have the honor of presenting you a report showing the results of the experiments made September 9th with the American Engine No. 9 of the "Consolidation" type.

This machine has coupled wheels 0.914 metres diameter (36 inches); and the weight on the drivers is 25,400 kilograms (56,000 pounds). The time used in obtaining a pressure of 120 pounds after firing was two hours and thirty minutes without forcing the fire, and the fuel consumed was 213 kilograms (470 pounds). During the trial the weather was fair but moist. The machine drew a train composed of nine cars weighing 27,439 kilograms (60,476 pounds), loaded with 170 rails weighing 33,825 kilograms (74,415 pounds), or a total of 61,264 kilograms (135,069 pounds).

The profile of the road where the trial was made shows a rising grade of 3 per cent. The throttle-valve was opened wide. The detent was set at $\frac{4}{10}$ of its course. The maximum speed observed was 17 kilometres (10½ miles). A speed of 15 kilometres (9.3 miles) was easily maintained. The effective pressure in the boiler varied from 130 to 150 pounds. The wheels slipped at various points on the line, sometimes on curves, sometimes on tangents. The slipping always took place during the passage of the machine over wet rails. At Station No. 40 of the second subdivision the slipping was so bad that we were obliged to stop. In spite of the sand the machine was not able to cross this point, which was on a curve. The injectors worked very badly. The feed was imperfect, and we lost nine minutes in the 51 kilometres from this cause. The consumption of fuel was 304 kilograms (670 pounds) during the run of 11,800 metres (38,547 feet) up the 3 per cent. grade. The time spent in traversing this space was 53 minutes, stops being deducted. The speed was consequently a mean of 13,360 metres (13 miles nearly) per hour. The fuel consumed for this space was 304 kilograms, say 25.762 kilograms (56.67 pounds) per kilometre (0.62 mile). The consumption of water was 4 cubic metres, say 0.340 metres (90 gallons) per kilometre (145 gallons per hour nearly). The tractive force as calculated was 60,000 kilograms (132,000 pounds), which completely corresponds with the results obtained. The various working parts were oiled at the start, besides which it was necessary to oil during the run both the guides and the cylinders, which absorbed 0.350 kilograms (0.77 pounds) of grease.

The tender has but one brake, which is not sufficient, and it will be necessary to apply one with greater power. The descent was accomplished with a French appliance furnishing a brake against the steam.

To resume, it is incontestable that this machine ("Consolidation" type) will render very good service on the second section. In passing around curves it operates very easily; the stability is very good, as also its motion. The consumption of coal is in accord with the water evaporated, and is rather large.

Such are, sir, the observations I have made in these experiments.

(*Signed*) EM. BERLAY,
Engineer.

CLASS 10-26 E ON GRADE OF 370 FEET PER MILE.

DENVER AND RIO GRANDE RAILWAY COMPANY.
COLORADO SPRINGS, COL., November 29, 1881.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Upon receipt of your letter of the 18th, I referred it to Mr. J. R. de Remer, who returned it to me endorsed as follows:

The 370 feet grade is the maximum on all tangents. Maximum curvature, 24°. Equation on all curves is 0.55 per degree, which will equal grade of 306.24 per mile on a 24° curve. We have never up to this date given the 406 a fair trial to test her power on this heavy grade. The most cars hauled by her at any one time up to date has been six construction box cars loaded with men, stores, and blankets, etc. My opinion is that Baldwin locomotive No. 406 will start and haul 65 or 70 tons with ease on the 370 feet grade. Respectfully,

(*Signed*) R. F. WEITBREC,
Manager Construction.

February 4, 1882.

Sample says to-day that the best that Engine 406 has ever done was to haul up 57 tons, consisting of cars and paying weight. This was under most favorable circumstances. Thinks average capacity is about 50 tons.

(*Signed*) R. F. WEITBREC.

CLASS 10-26 E ON GRADE OF 140 FEET PER MILE.

OFFICE OF THE EAST BROAD TOP RAILROAD AND COAL CO.
ORBISONIA, HUNTINGDON CO., PA., 8th June, 1882.

BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Your letter of the 5th addressed to our President, Mr. Ingham, has been referred to me.

With regard to the performance of our 16 × 20 cylinder "Consolidation" engine:

Our maximum grade, as mentioned in a previous letter, is 140 feet per mile, 3 miles in length. On this grade we have several curves of 574′ and 478′ radius, and one of 338′, with reverse curves of longer radius.

Our schedule time over this portion of the road is a little over 10 miles per hour, with twenty empty coal dumps and cabin car, weighing 104½ tons of 2000 lbs., exclusive of tender.

On the return trips from the mines we consider twenty-seven loaded cars, containing 9¼ tons each, or a total of 384¾ tons, with the cabin car, a fair load over an adverse grade of $52\frac{8}{10}$ feet per mile at the rate of 15 miles per hour.

Finding the engine too large for our turn-tables, I abandoned those at each end of the road and substituted V tracks with 23° curves on each arm. These it passes over daily with perfect ease.

I have no doubt but that the engine would haul more than we have ever put her down to. Unfortunately, we are obliged to run her at a much higher rate of speed than is advisable for an engine with driving-wheels 36 inches in diameter. I have, therefore, not attempted to work the engine up to the full hauling capacity. Yours truly,

(*Signed*) A. W. SIMS,
Superintendent.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FREIGHT LOCOMOTIVES, "DECAPOD" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

General Design shown by Photograph on page 34.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF ONE SIZE OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
12-30 F	18 × 20	37	13	18 8		2000	86,000	75,000	2040	820	500	350	260	205	170

This class of locomotive is offered for service where the weight of rail is such that it is desirable to distribute the adhesive weight on ten driving-wheels. As something less than 8000 pounds are carried on each driving-wheel, an engine of this class could be used on iron rails weighing 40 pounds per yard.

The fire-box can be adapted to burn either wood or coal.

The total wheel-base of engine and tender is 46 feet 1 inch. Adding, say, 18 inches for clearance of flanges, a turn-table 47 feet 7 inches diameter will be required.

PERFORMANCE OF A NARROW-GAUGE "DECAPOD" LOCOMOTIVE.

CLASS 12-30 F ON GRADE OF 200 FEET PER MILE.

THE MEXICAN NATIONAL CONSTRUCTION CO., NEW YORK, April 6, 1883.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Mr. Purdy sends the following as the result of a trial trip of a "Decapod" engine between Mexico and Summit, with a train of

Eight eight-wheeled cars, loaded with 12 tons each, making a total of	281,056 pounds.
One four-wheeled caboose	8,675 "
Total weight of cars and load	289,731 pounds.

Pine wood consumed, 3.75 cords. Distance run, 39.12 kilometres. Gradients are as follows:

Level	9.18 kilometres.
1 per cent. ascending	5.10 "
2½ " "	7.81 "
$3\frac{8}{10}$ " "	17.3 "

Mr. Purdy expects shortly to have several experiments made with these engines, so as to get an average, as the circumstances of this particular trial were more favorable to the engine than usual; and he will also have some experiments made with the "Consolidation" engines and send me the comparative statement, which I will send to you as soon as received.

(*Signed*) WALTER HINCHMAN,
President.


G. & B. R. R.
JOHN GUNK.
171.


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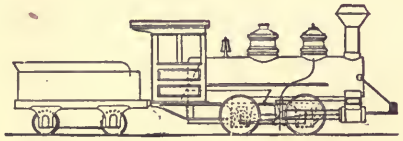
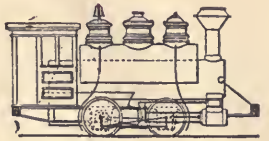
FOUR-WHEELS-CONNECTED NARROW-GAUGE SWITCHING LOCOMOTIVES,



WITH SEPARATE TENDERS OR TANKS ON BOILERS.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

General Design shown by Photographs on pages 38 and 40.



DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF EIGHT SIZES OF THIS PATTERN.

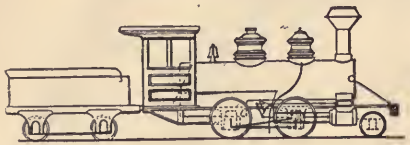
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
										26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
4- 8 C	7 × 12	24 to 26	3 10	3 10	200	400	10,000	10,000	270	105	65	45	35	25	20
4-10½ C	8 × 12	26 to 28	3 10	3 10	250	450	13,500	13,500	370	150	90	65	50	35	30
4-11 C	9 × 14	28 to 30	4 6	4 6	300	500	16,000	16,000	435	175	105	75	55	45	35
4-12 C	9 × 16	33 to 36	5	5	350	600	20,000	20,000	545	220	135	95	70	55	45
4-14 C	10 × 16	33 to 36	5	5	400	700	23,000	23,000	625	250	155	110	85	65	55
4-16 C	11 × 16	33 to 36	6	6	450	800	26,000	26,000	710	285	175	120	95	70	60
4-18 C	12 × 18	36 to 39	6	6	500	900	30,000	30,000	820	330	200	140	105	85	70
4-20 C	13 × 18	36 to 39	6	6	550	1000	35,000	35,000	980	400	240	170	130	100	85

In referring to any of the above classes, it should be stated whether a locomotive with separate tender or with tank on boiler is meant.

In case of a locomotive with separate tender, the tender can be 4-wheeled, 6-wheeled, or 8-wheeled, as preferred, according to capacity required.

The weights given in above table and the figures for loads to be hauled are predicated on locomotives with separate tenders. A tank engine of any given class would weigh approximately, when tank is full, 8⅓ pounds in addition for each gallon in tank. Thus Class 4-20 C would weigh about 40,000 pounds, with tank, containing 550 gallons of water, on boiler. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 5 to 10 tons.

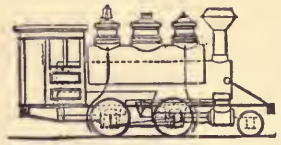
FOUR-WHEELS-CONNECTED AND LEADING PONY TRUCK NARROW-GAUGE LOCOMOTIVES,



FOR SWITCHING OR LOCAL SERVICE, WITH SEPARATE TENDER OR TANK ON BOILER.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

General Design shown by Photographs on pages 43 and 45.



DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF FIVE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
6-12 C	9 × 16	37 to 41	6	12	350	600	25,000	19,000	460	180	110	75	55	40	35
6-14 C	10 × 16	37 to 41	6 3	12 4	400	700	28,000	22,000	570	225	135	95	70	55	45
6-16 C	11 × 16	37 to 41	6 6	12 10	450	800	32,000	26,000	705	280	170	115	90	65	55
6-18 C	12 × 18	39 to 45	7	13 6	500	900	38,000	30,000	815	325	195	135	100	80	65
6-20 C	13 × 18	39 to 45	7 4	13 10	550	1000	42,000	34,000	920	370	220	155	115	120	75

This plan of engine necessarily has a shallow fire-box placed over rear driving-axle. It is, therefore, best adapted to burning coal, but wood may also be used as fuel with fair results.

Two pairs of wheels are equalized together longitudinally, either the coupled wheels, or the front driving-wheels with the pony truck.

The pony truck has a swinging bolster and radius bar. Owing to the action of the truck, the shortness of the total wheel-base and the short spread of the coupled wheels, an engine of this type, when running with the truck ahead, can traverse readily the sharpest curves.

The weights given in above table and the figures for loads to be hauled are predicated on locomotives with separate tenders. A tank engine of any given class would weigh approximately, when tank is full, 8⅓ pounds in addition for each gallon in tank. Thus Class 6-20 C would weigh about 47,000 pounds, with tank, containing 550 gallons of water, on boiler. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 5 to 10 tons.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FOUR-WHEELS-CONNECTED AND TWO-WHEELED TRAILING TRUCK NARROW-GAUGE LOCOMOTIVES,

"FORNEY" TYPE, FOR SWITCHING AND LOCAL SERVICE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

General Design shown by Photograph on page 48.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF EIGHT SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.		Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
												26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
6- 8⅓ C	7 × 12	28	3	8	8	8	225		15,000	10,000	270	105	65	45	35	25	20
6-10⅓ C	8 × 12	28 to 30	3	9	9	7	250		19,000	14,000	380	155	95	65	50	40	30
6-11⅓ C	9 × 14	30	4		10		350		24,000	17,000	465	185	115	80	60	50	40
6-12⅓ C	9 × 16	33 to 37	4	6	10	9	400		27,000	20,000	520	210	125	90	70	55	45
6-14⅓ C	10 × 16	33 to 37	4	6	10	9	450		31,000	23,000	630	255	155	110	85	65	55
6-16⅓ C	11 × 16	33 to 37	5		11	6	500		35,000	26,000	710	285	175	125	95	75	60
6-18⅓ C	12 × 16	33 to 37	5		11	9	550		40,000	30,000	820	330	200	145	110	85	70
6-20⅓ C	13 × 18	37 to 41	5	6	12	6	600		45,000	34,000	930	375	230	160	125	100	80

The weights given in above table include water in tanks. In this type the driving-wheels are equalized together, and the truck is centre bearing, with swinging bolster and radius bar. For traction on short lines, and where limited tank capacity is admissible, this type has the following advantages:

First. Having six wheels, it is comparatively steady on the track, and moves smoothly and without plunging, causing the least wear to the track and itself.

Second. The fuel and water are carried on the engine frames at the back. The centre of gravity of the engine is thus kept low, and the boiler is left unobstructed when any repairs are required by it.

Third. The distribution of weight is as nearly perfect as possible, and the principal weight is carried on equalizing levers midway between the driving-wheels. This gives an equal distribution of the weight on the four driving-wheels. The pony truck carries the weight of the water and fuel, with part of the weight of the overhanging fire-box.

Fourth. The engine can be run either way without turning, and will pass curves readily. As the weight is carried on the two fulcrums of the side equalizers between the driving-wheels and on the centre pin of the pony truck, every wheel finds a bearing, however uneven the track may be.

Fifth. The plan admits of a fire-box of ample length and width. For tracks of 30 inches gauge or less, the fire-box can be made wider than the gauge of track.

FOUR-WHEELS-CONNECTED AND FOUR-WHEELED TRAILING TRUCK LOCOMOTIVES,

"FORNEY" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

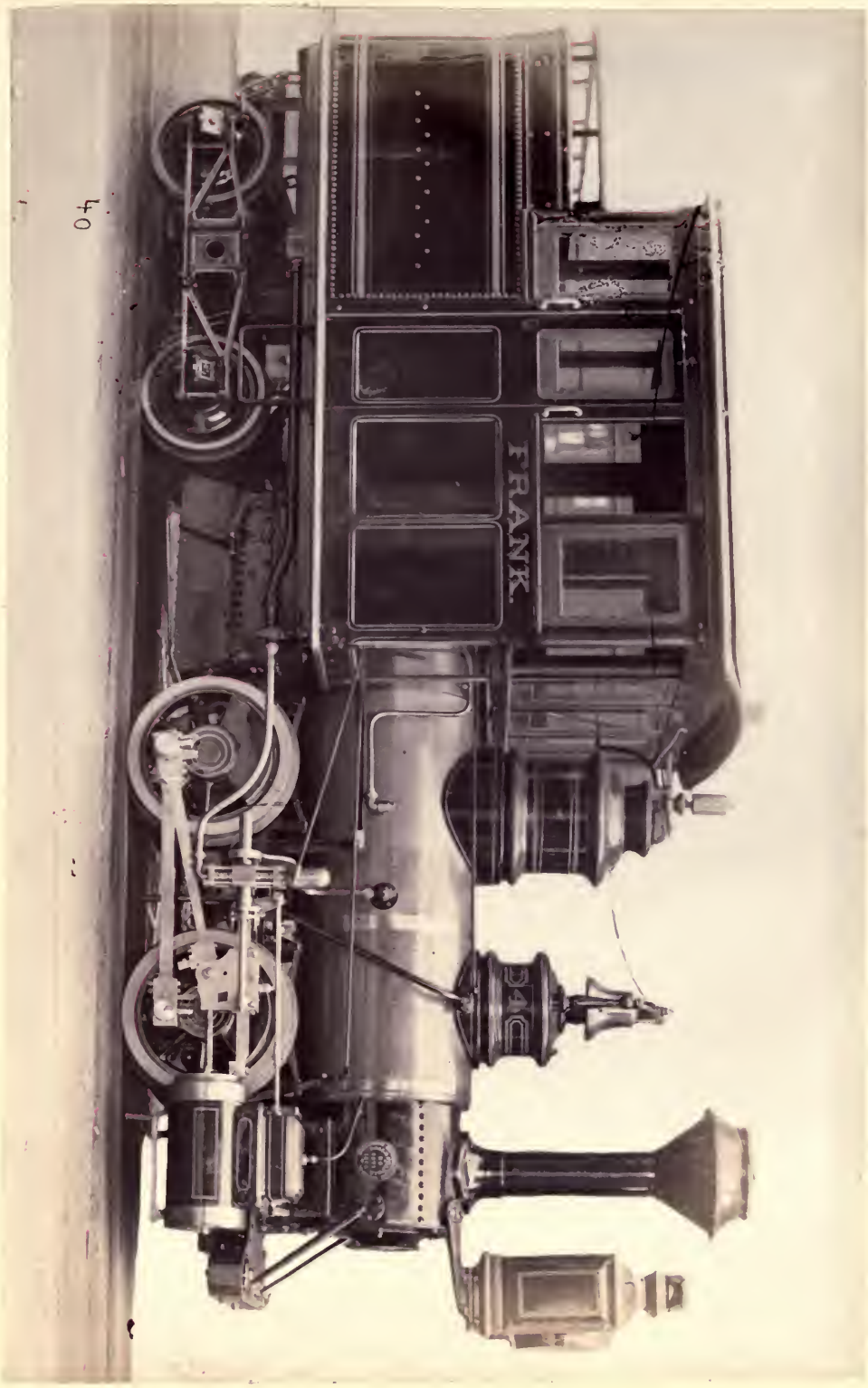
General Design shown by Photograph on page 51.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-11⅓ C	9 × 14	30	4	14 4	450		26,000	17,000	465	185	115	80	60	50	40
8-12⅓ C	9 × 16	33 to 37	4 6	15 1	500		30,000	20,000	520	210	125	90	70	55	45
8-14⅓ C	10 × 16	33 to 37	4 6	15 1	550		34,000	23,000	630	255	155	110	85	65	55
8 16⅓ C	11 × 16	33 to 37	5	15 7	600		38,000	26,000	710	285	175	125	95	75	60
8-18⅓ C	12 × 16	33 to 37	5	15 10	650		42,000	30,000	820	330	200	145	110	85	70
8-20⅓ C	13 × 18	37 to 41	5 6	16 6	700		47,000	34,000	930	375	230	160	125	100	80

The weights given in above table include water in tanks.

The same considerations as are stated on page 49 for locomotives with trailing pony trucks are applicable to the above classes.


FRANK.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FOUR-WHEELS-CONNECTED AND LEADING AND TRAILING TRUCK "DOUBLE-ENDER" LOCOMOTIVES.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

General Design shown by Photograph on page 54.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SEVEN SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
										26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-10¼ C	8 × 12	37	4 6	15 10	350		22,000	12,000	270	95	65	45	30	25	20
8-11¼ C	9 × 14	37	4 6	15 10	400		27,000	15,000	405	160	100	70	50	40	30
8-12¼ C	9 × 16	37 to 41	5	17 9	450		30,000	18,000	460	185	115	80	60	50	40
8-14¼ C	10 × 16	37 to 41	5	18 2	500		36,000	22,000	570	230	140	100	75	60	50
8-16¼ C	11 × 16	37 to 41	5	18 6	550		42,000	26,000	680	275	165	115	90	70	60
8-18¼ C	12 × 18	41 to 45	5 8	20	650		48,000	31,000	845	340	205	145	110	80	70
8-20¼ C	13 × 18	41 to 45	5 8	20 4	700		56,000	36,000	980	400	240	170	130	100	85

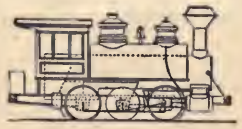
The weights given include weights of water in tanks. This type of engine is offered as the most perfect for service with moderate loads, where it is desirable to run both ways without turning, and with water stations a short distance apart. It has the following advantages:

First. The springs of the rear driving-wheels and of the rear truck are connected by side equalizing levers, so that the back of the engine is carried on two side bearings at the fulcrums. The springs of the front driving-wheels and of the front truck are connected by a central equalizing lever which carries the front of the locomotive on a central bearing. The engine will, therefore, ride smoothly, and all the wheels will find a bearing even on the most uneven track.

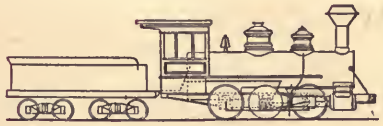
Second. Each truck has a swinging bolster and radius bar, so that the engine will pass short curves with facility.

Third. The truck at each end largely guides the engine on curves, and thus relieves the flanges of the driving-wheels of excessive friction.

If preferred, the tank can be placed on an extension of the frames back of the cab instead of on the boiler. In this case, however, it will necessarily be of less capacity than the tank on the boiler, and, combined with weight of the fire-box, will throw an undue proportion of weight on the rear wheels.



SIX-WHEELS-CONNECTED LOCOMOTIVES.



GAUGE, THREE FEET, OR WIDER.
FUEL, WOOD OR COAL.

General Design shown by Photographs on pages 57 and 59.

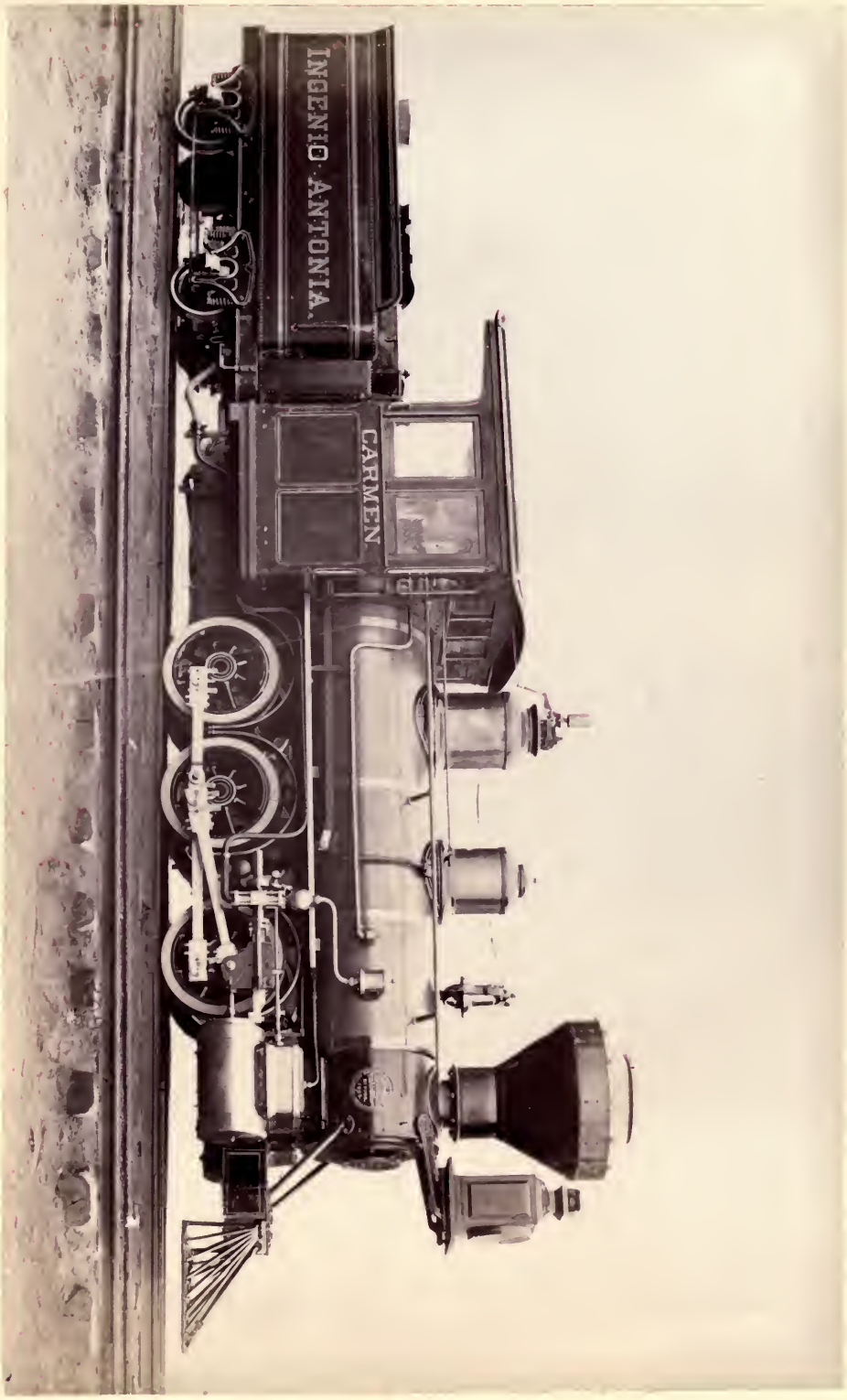
DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF EIGHT SIZES OF THIS PATTERN.

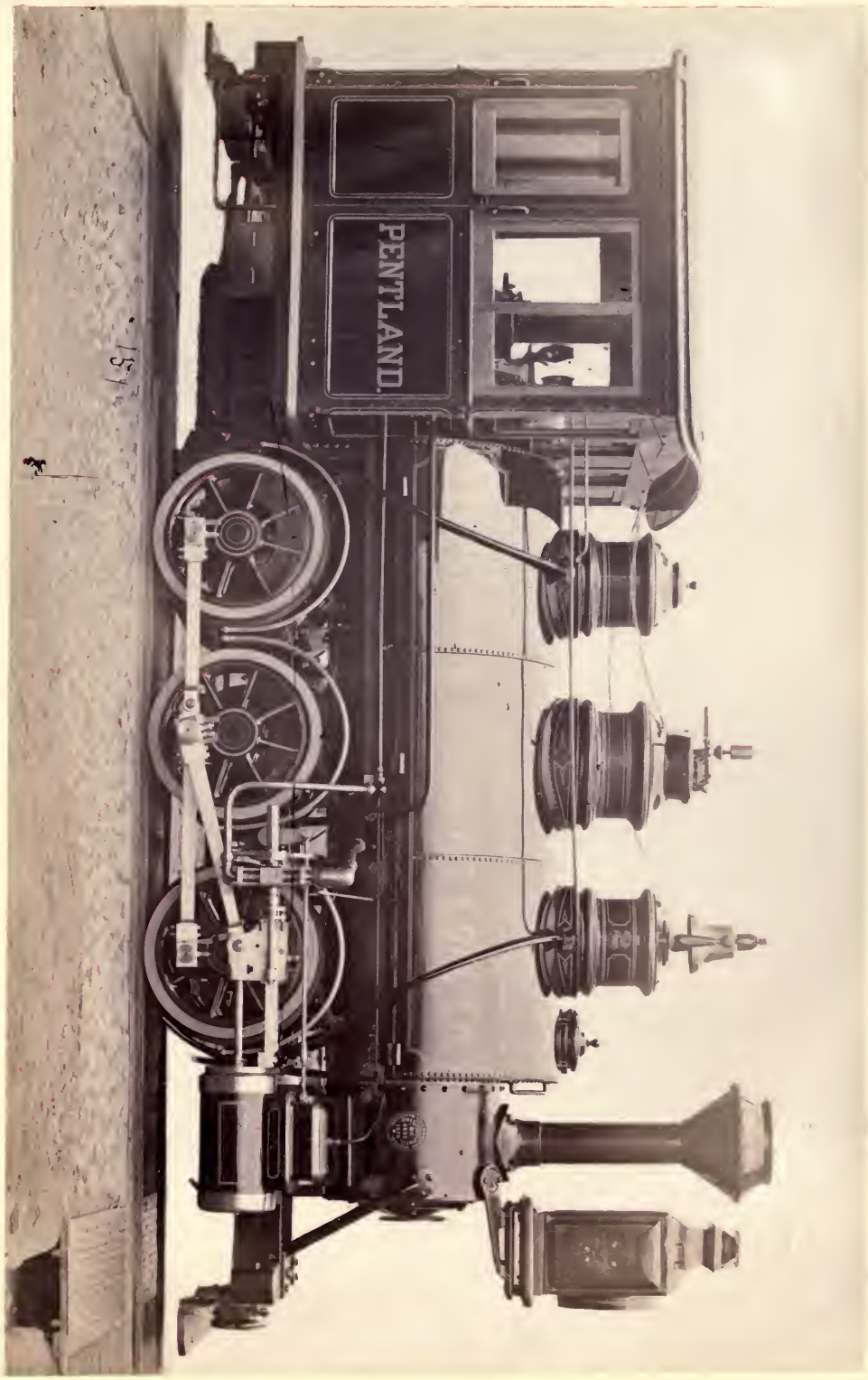
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.						On a Level.	On a Grade per Mile of					
							Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
6-11 D	9 × 14	30 to 33	6	3	6	3	300	600	21,000	21,000	500	205	125	90	70	55	45
6-12 D	9 × 16	33 to 37	6	9	6	9	350	750	26,000	26,000	550	225	140	100	75	60	50
6-14 D	10 × 16	33 to 37	7	5	7	5	400	900	30,000	30,000	650	260	160	110	85	65	55
6-16 D	11 × 16	33 to 37	7	7	7	7	450	1000	33,000	33,000	790	315	190	130	100	80	65
6-18 D	12 × 18	37 to 41	7	7	7	7	500	1100	36,000	36,000	950	385	235	165	125	95	80
6-20 D	13 × 18	37 to 41	8		8		550	1200	40,000	40,000	1090	440	265	190	140	110	90
6-22 D	14 × 18	37 to 41	9	6	9	6	600	1300	44,000	44,000	1200	485	295	210	160	125	100
6-24 D	15 × 18	37 to 41	9	6	9	6	650	1400	48,000	48,000	1310	530	320	225	170	135	110

In referring to any of above classes, it should be noted whether an engine with separate tender or tank on boiler is meant.

In case of a locomotive with separate tender, the tender can be 4-wheeled, 6-wheeled, or 8-wheeled, as preferred.

The weights given in above table and the figures for loads to be hauled are for engines with separate tenders. In the case of tank engines, the weights would be increased approximately in the ratio of 8⅓ pounds for each gallon of water in tank. Thus, Class 6-22 D, with tank on boiler, would weigh about 49,000 pounds with tank full of water. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 5 to 10 tons.


INGENIO ANTONIA
CARMEN


PENTLAND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SIX-WHEELS-CONNECTED AND TRAILING TRUCK LOCOMOTIVES, "FORNEY" TYPE.

GAUGE, THREE FEET, OR WIDER. FUEL, WOOD OR COAL.

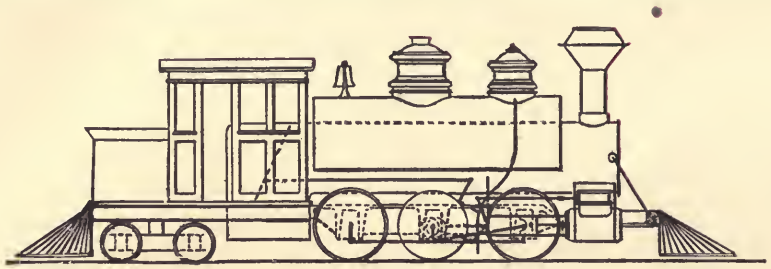
General Design shown by Photograph on page 62.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

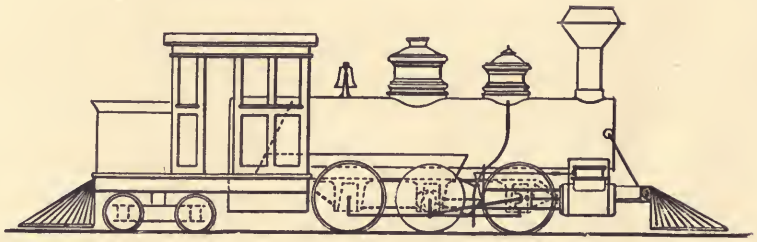
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
										26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-12½ D	9 × 16	33 to 36	7 2	13 5	400		28,000	20,000	555	230	145	105	80	65	55
8-14⅓ D	10 × 16	33 to 36	7 2	13 5	450		32,000	23,000	655	265	165	115	90	70	60
8-16⅔ D	11 × 16	33 to 36	7 2	13 8	500		36,000	26,000	795	320	195	135	105	85	70
8-18⅓ D	12 × 18	36 to 39	7 8	14 5	550		43,000	33,000	955	390	240	170	130	100	85
8-20⅔ D	13 × 18	36 to 39	7 8	14 8	600		48,000	37,000	1095	445	270	195	145	115	95
8-22½ D	14 × 18	36 to 39	7 8	14 11	650		54,000	43,000	1205	490	300	215	165	130	105

The weights given in above table include water in tanks.

In this type the three pairs of driving-wheels are equalized together. The pony truck is centre bearing and independent, and has a swinging bolster and radius bar. The engine will be somewhat steadier in its movement than the type shown on page 57, and will curve more readily and with less wear of flanges of rear driving-wheels when running backward.



10½ D, with Tank on Boiler.



10½ D, with Tank Back of Cab.

The type of locomotive described in preceding table (page 63) can be constructed with a 4-wheeled truck in place of the 2-wheeled truck, if preferred.

The water tank can be placed on the boiler or back of the cab and over the truck. If on the boiler, its capacity can be made much larger. In this case the space back of the cab can be utilized entirely for fuel.